˟ SFOF Digital Television Display Subassembly

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This article describes the Space Flight Operations Facility (SFOF) digital television display subassembly, which is a part of the digital television assembly. It accepts input digital data from the computer subassembly, converts it to video data, stores it and provides a continuous television-compatible video output which is distributed throughout the SFOF. The display subassembly consists of a system control unit, four display generator units and various hardcopy generation equipment.

I. Introduction

The digital television display subassembly is a part of the digital television assembly (DTV) of the user terminal and display subsystem in the SFOF. The purpose of the DTV is to provide flight projects and DSN users with volatile real-time displays of spacecraft data and DSN equipment status. As a part of the DTV, the display subassembly provides a digital-to-video conversion capability with storage and refresh capability for multiple channels of alphanumeric and graphic information display. This subassembly is shown in Fig. 1. The display subassembly and the computer subassembly make up the DTV. This article supplements two previous ones on the DTV (Ref. 1) and the computer subassembly (Ref. 2).

The display subassembly includes interfacing equipment, display generation equipment and hardcopy equipment. This article provides details on the display subassembly design approach, interface characteristics, and display generation capability. "SFOF Digital Television Hardcopy Equipment," by K. Kawano and F. L. Singleton in this issue, discusses the hardcopy generation capability.

II. Display Subassembly Requirements

Within the DTV, the display subassembly's primary purpose is the conversion of digital information into a video format and outputting this video data. To achieve this purpose, the display subassembly must be able to accept formatted digital data, convert this data into a video signal containing alphanumeric and graphic data suitable for TV display, provide multichannel storage of the video signals, and constantly refresh the video signal outputs to the TV displays.

Because the display subassembly outputs are distributed to standard TV monitors, these video outputs must meet standard TV format requirements. This format is as follows: A standard TV frame consists of a horizontal raster of 480 visible scan lines. Each frame consists of two fields A and B with 240 visible scan lines each. The two fields are scanned on the television screen alternately so that the 240 scan lines in one field physically interlace with those of the other field. The rate at which the fields are scanned is 60 per second, a rate which is sufficiently fast to appear to the human eye as a single visible display. In order to update data on the screen, the display subassembly must be able to address specific locations on the screen in either field.

III. Design Approach

The input to the display subassembly is digital data from the computer subassembly. The system control unit (SCU) serves as the interface between the computer subassembly and the display subassembly. Digital data is accepted by the SCU and passed on to the display generators or the hardcopy equipment.

The conversion of digital data into TV-compatible video data required, digital data buffering, logic for channel selection, alphanumeric character generation, graphic data generation, address location, and timing synchronization. These functions were combined into a display generator unit for each 20 DTV channels.

In order to provide multichannel storage for video data, a mass storage device was required. To be TV-compatible required constant refreshing of display outputs in synchronism with the existing TV distribution equipment. The design approach which satisfied both mass storage and constant refreshing was a rotating mass memory device. A disk memory was selected for this design because it was a rotating mass memory device that could be synchronized to the TV distribution equipment. Storage for 20 DTV channels was provided on each of four disk memory units.

Input and output interfaces to the disk memory and amplifiers for video output were included in the display generator logic, providing common logic for 20 DTV channels in each of four display generators.

Because the data conversion and storage capability was provided in 20 channel increments, future expansion capability was made by allowing interfaces for up to six display generators on the SCU. This provision permits expansion to 120 channels.

IV. Functional Description of the DTV Display Subassembly

This subassembly consists of the following units: one system control unit, four display generators, one display image buffer, twelve copy request units and twelve hardcopy printers (Fig. 2).

The display image buffer, copy request units, and hardcopy printers are all part of the hardcopy equipment.

Each of these units has been provided to meet the requirements for the display subassembly. In the following discussion, the functional aspects of the display subassembly are described in an attempt to provide a better understanding of how the design approach has been implemented.

V. Digital Input Interface

The display subassembly under the control of the computer subassembly generates video displays and hardcopy outputs. The SCU interfaces with the computer subassembly and provides overall integration of the display subassembly. Although the SCU receives two input sources from the computer subassembly, only one input at a time can have control of the SCU and therefore of the display subassembly. SCU circuitry locks out the second input when the first is connected until a complete message is transferred.

The SCU, acting much like a peripheral controller to the computer subassembly, routes the data and instructions to the computer-specified unit in the display subassembly. The SCU, as commanded by the computer subassembly, connects to a specific device (such as a display generator) and transfers the incoming digital data to that device on a demand-response basis.

In addition to data routing, the SCU also provides a data translation function by packing two 12-bit bytes input from the computer subassembly into one 16-bit word for output to the display generators. Unused portions of each 12-bit byte are discarded.

VI. Display Generation

Four display generators are attached to the SCU by a common data bus. Only one display generator at a time is selected for data transfer. Each of these units is identical to the other and contains the necessary logic for data conversion and output to the TV monitors. A block diagram of the display generator is shown in Fig. 3. The various logic blocks shown in that figure are used in the discussion to follow.

The data to be displayed on the DTV channels may be alphanumeric or graphic. Each display generator has both alphanumeric and graphic data generation capability. The alphanumeric characters consist of 96 characters selectable by standard 7-bit American Standard Code for Information Interchange (ASCII) codes. The

graphic data can be displayed in several modes as selected by instructions in the digital buffer memory; either as specific 8-bit patterns contained in the data, as 8-bit by 12-line matrix of data bits contained in the data, or as horizontal and vertical line segments with specified start and end points. The graphics capability discussed is the inherent hardware capability within the display subassembly.

Within the connected display generator, all instructions and data are first transferred into a digital buffer memory. The digital buffer can store up to 256 16-bit words, either instructions or data. It also holds these instructions and data so that they can be output repeatedly, when required in generating characters or other display data on more than one line or field of the screen.

To generate video displays, the display generation logic reads out data in sequence from the digital buffer memory. The general sequence of data read out from the digital buffer is as follows: (1) an instruction selecting the mode of operation (e.g., alphanumeric or graphic) is output to the control logic; (2) an instruction selecting the DTV channel and the corresponding disk memory channel is output to the channel select logic; (3) instructions selecting the starting X and Y addresses are loaded into the element and line address registers; and (4) these instructions are followed by alphanumeric or graphic data.

The channel select logic enables the correct gating in the write electronics so that data can be written on the selected channel. The element and line address registers store the addresses for selecting the appropriate location on the disk memory.

In order to convert alphanumeric data into a video display output, the data is transferred from the digital buffer to the character data generation logic. There the ASCII code selects the corresponding matrix from the alphanumeric read-only-memory. Then, sequential readout of the correct bit pattern from the read-only-memory occurs when the disk memory reaches the desired X and Y locations. With graphic data, the digital data is transferred through the graphic data generation logic.

The data selection and control logic selects either alphanumeric inputs from the alphanumeric read-only-memory or direct graphic data inputs from the graphic data generation logic and presents them to the input of the write electronics.

When the element and line address stored in the X and Y registers agree with the actual disk position as read out by the element and line counters, the comparison logic causes the write enable logic to command the write electronics to write data on the disk memory channel selected. Data written on a disk memory channel is automatically output as video data which is then displayed on the TV screens throughout the SFOF.

The display information may consist of up to 3200 alphanumeric characters in the 96-character ASCII set, any of various graphic modes, and may be positioned anywhere on a television screen. Alphanumeric or graphic data can be individually added or deleted without disturbing an existing display. The display generation logic can generate dark images on a light background or light images on a dark background, as well as generate four selectable character sizes.

VII. Timing Considerations

In all modes of operation, it is important to write the video bit patterns on exact locations of the disk which correspond to the desired television screen location. To accomplish this correspondence, a prerecorded clock signal from the disk memory is output to the element (X) and line (Y) counters of the display generator. The element and line counters count the stored clock signal and issue a binary code that designates the exact position of the rotating disk. The position of the disk is compared with the desired starting position for writing the next byte of information. A write-enable signal is generated at coincidence of these positions and remains enabled until the control logic determines the end of the operation in progress.

VIII. Disk Memory Data Storage

The video bit pattern generated by the display generator is stored on 80 tracks of a disk memory and then used to generate or refresh a video display on 20 video channel outputs. The data bits are written on the disk on four parallel tracks per DTV channel simultaneously at a nominal 3 MHz rate. The write data bits are stored 4-bits in parallel on the disk, but when read from the disk, are shifted from a parallel to a serial 12-MHz bit stream. Each stored data bit corresponds to an element address on the television monitor screen.

Data bits are written as either a logic 1 or logic 0 signal by the write electronics. The data bit written as

a logic 1 is caused by a flux transition in one direction and a data bit written as a logic 0 is caused by a flux transition in the opposite direction on the surface of the disk.

The manner in which the element and line counters count allows data to be recorded on the disk memory in a format identical to the horizontal scan television raster. It is recorded basically in the same time sequence as it is displayed on the TV screen. However, since physical location on the disk surface corresponds to a physical location on the screen, the individual elements of each line plus retrace and blanking times must be allowed for in disk recording. Also, since most data is recorded on both fields of the display, the data must be recorded on the disk on the first recorded field and on the second recorded field, half a revolution away on the disk.

This means that nearly all digital input data must be held over for processing on both fields of the disk memory (and display). The digital buffer memory is utilized to accomplish this. Data can be read from the digital buffer once for processing in field A and then read out again, 1/60th of a second later, for processing in field B. Data is held in the digital buffer until it is no longer required for display generation.

IX. Video Output Distribution

Each of the four display generators provides conditioning of the twenty disk memory channel outputs to provide a continuous noncomposite video signal output through video amplifiers to the television distribution equipment for 80 DTV channels. This equipment distributes these 80 channels to TV monitors throughout the SFOF.

This conditioning provides the correct signal levels and impedances but the manner in which the video data is recorded on the disk memory provides the proper TV-compatible signal content.

The video output frequency and frame synchronism are directly related to the disk memory rotation. Correct video output transmission has been accomplished by synchronizing the speed of rotation of the disk memory in each display generator to the SFOF-supplied TV sync. A servo control unit is associated with each disk memory which derives its output from the TV synchronizing signals. This output provides speed control signals to the disk memory motor and matches its speed to the TV sync rate.

Each rotation of the disk memory will cause one complete TV frame to be output per DTV channel. When this disk is synced to the TV sync source, it will rotate at 30 rev/s, producing a 30-frame/s or 60-field/s output rate.

X. Hardcopy Interface

Each display generator supplies a one channel video bit pattern output for use in hardcopy generation. Under control of the display image buffer (DIB), the DIB monitor channel in each display generator can be switched to output any one of the twenty DTV channels in that display generator. This data is presented to the DIB for use in recording and printing a hardcopy of any DTV channel.

XI. Conclusion

The DTV display subassembly was designed to meet the requirements for digital-to-video conversion, storage, and refresh of 80 video output channels. This design utilizes disk memories for video storage and refresh, and provides input digital buffering to allow optimum use of the disk memories. The resultant video data is ready for output to the existing television monitors used throughout the SFOF. This display has been operating in support of the current DSN commitments to *Mariner* '71 since January, 1971. The expanded 80-channel capability and hardcopy expansion were installed in March, 1971, in preparation for expanded DSN support for the *Pioneer F* mission.

References

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2. Leach, G. E., "SFOF Digital Television Computer Subassembly," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. III, pp. 175–178. Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1971.
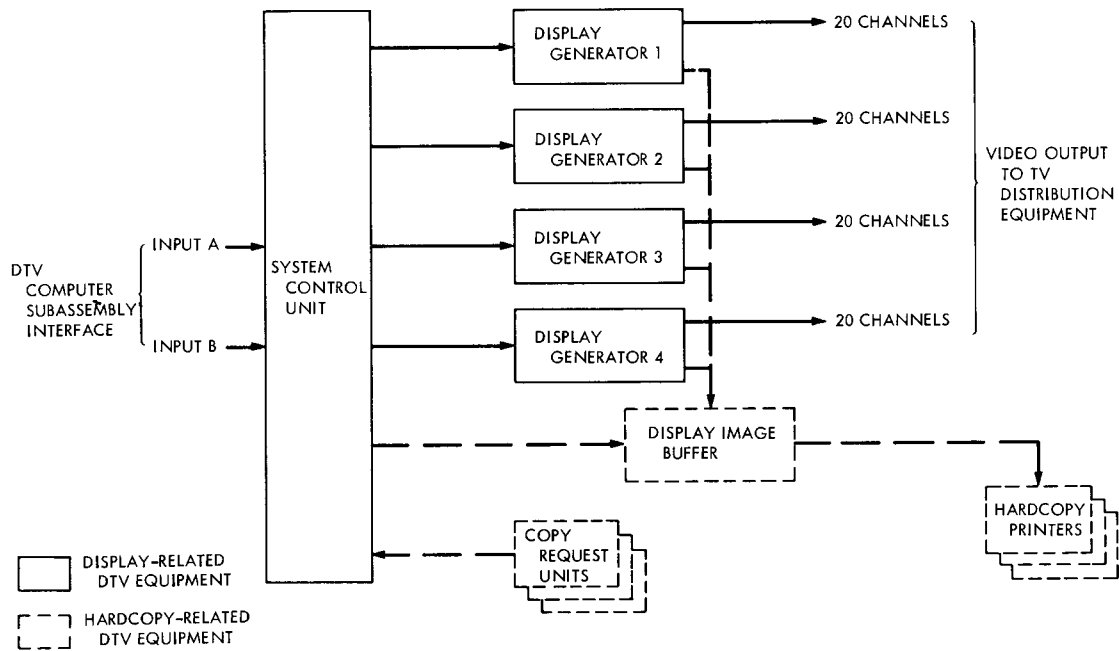
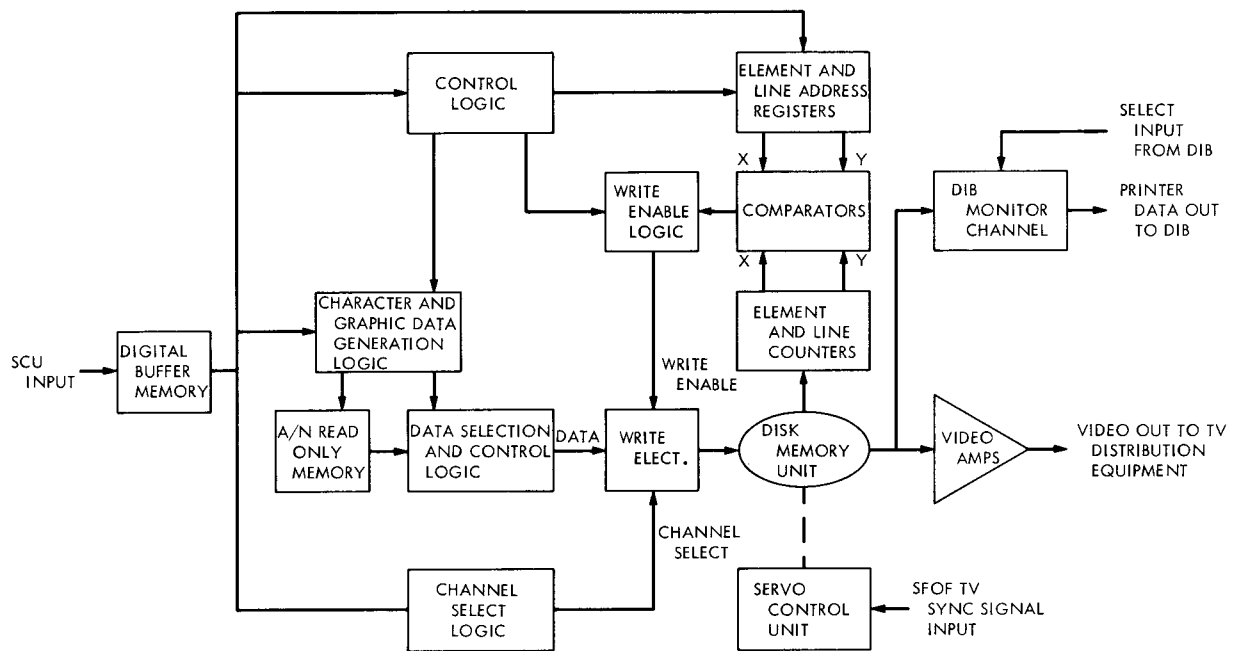Fig. 1. DTV display subassembly

Fig. 2. DTV display subassembly block diagram

Fig. 3. Display generator block diagram